11. The manufacturer's computer calculations for a DC-9-31 aircraft in the same configuration as Flight 340 for a condition where the runway braking coefficient is near zero (dynamic hydroplaning) show a stopping distance of 4,403 feet after touchdown, using maximum reverse thrust (2.0 EPR) and spoilers only at the higher touchdown speed of 135 KIAS. The same calculations, using a touchdown speed of 124 KIAS, show a stopping distance of 3,998 feet after touchdown. It should be noted, however, that these calculations do not take into consideration any loss of reverse thrust at the slower speeds resulting from reinjestion of the exhaust gases into the engines.

12. At the landing weight and speed of the aircraft at touchdown with the existing runway conditions, the Board believes that more than the remaining useable runway length was necessary to stop the aircraft.

13. Correlation of the flight recorder and voice recorder shows that the aircraft had decelerated to 57 KIAS at a point 132 feet off the end of the runway, where the aircraft hit a fence and street curb.

14. No rubber reversion was found on any of the tires; however, there was a skid patch found on each of the left main landing gear tires at an angle of 10°, -15° off centerline, indicating a yaw to the left when this occurred.

15. Examination of the last 1,400 feet of the runway revealed white tire streaks, relatable to N938PR, which were of the type frequently exhibited in known cases of hydroplaning.

16. The passengers and crew evacuated from the aircraft without major difficulties.

Probable Cause

The Board determines that the probable cause of this accident was the loss of effective braking action caused by dynamic hydroplaning of the landing gear wheels on a wet/flooded runway. Contributing factors were a higher-than-normal touchdown speed and the location of the airport and its topography which permitted excess levels of water to accumulate on the runway.

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3. RECOMMENDATIONS AND CORRECTIVE ACTIONS

The Board considers that the landing limitations, as specified in Section 121.195 of the Federal Aviation Regulations for dry runways, are adequate. This requirement states essentially that the actual landing distance, from a point 50 feet above the runway threshold to rollout and full stop, must be within 60 percent of the available runway.

However, it is the Board's opinion that the empirical extra 15 percent of runway presently allowed for a wet runway condition is not adequate

for all wet or slippery runways since, in many instances, the wheel brakes are completely ineffective. It is interesting to note that for conditions attendant to this accident, according to the manufacturer's data, the aircraft could have been brought to a complete stop in 4,437 feet of runway using only spoilers and maximum continuous reverse thrust from a normal touchdown speed of 124 KIAS (i.e., without brakes). Thus, allowing for a 1,000-foot touchdown point and considering criteria based only on spoilers and reverse thrust, the wet runway requirement in this case would have been, theoretically, 122 percent of the FAR-required dry runway length (4,400 feet) or approximately 5,400 feet. In this case, therefore, the application of a weight limitation would have been necessary to conform with the 5,150 feet of runway available, if spoilers and reverse thrust were the only decelerative systems available.

In light of the above, the Board also examined stopping data for Boeing 727-100 aircraft using reverse thrust only. Applying the above principle, this data would give wet runway criteria factors for B-727-100 aircraft of 117 percent of the FAR-required dry landing field lengths at a landing weight of 100,000 pounds, ranging up to 130 percent at 135,000 pounds maximum landing weight.

It is clear to the Board that more attention to the wet or slippery runway problem is needed by the entire aviation community to cope with this problem adequately. The Board is cognizant of actions now being taken to minimize this problem, particularly in the areas of runway grooving, measurement of actual runway braking coefficients, and enforcement of the operators' responsibility to restrict operations into known hazardous runway conditions. However, the Board is concerned, since the problem becomes magnified with the advent of the high landing energy wide-body jets and consequent larger number of passengers exposed to this hazard.

In view of the foregoing, the Safety Board believes that the present criteria in Part 121 for determination of wet runway landing distances needs reevaluation. One possible method of determination might be based on stopping distances by the use of reverse thrust without credit for wheel braking. Another method was proposed by Messrs. Walter B. Horne of NASA and Howard C. Sparks, USAF, which was presented at the National Air Transportation Meeting in New York on April 20-23, 1970, and published in SAE paper 700265 which involves new techniques for the measurement of runway slipperiness by utilizing a diagonally braked automobile.

In regard to the latter, the Board has forwarded a letter to the Administrator recommending that the FAA evaluate this proposed NASA method for the measurement of runway slipperiness and compare results to the present FAR wet runway length requirements and consider the feasibility of incorporating the NASA traction test procedures in revised wet runway length requirements for air carrier operations. (See attachments for copy of Chairman's letter to the Administrator and the Administrator's reply.)

As an immediate corrective measure, the Virgin Islands Airport Authority has had the runway grooved, which has reduced the wet-to-dry runway stopping distances, for the major portion of the runway, to near unity (1.18:1) and for the portions of the runway where tire rubber is impregnated from a value of 2.17:1 to 1.71:1. The Board believes that the runway grooving program should be expedited and, when incorporated by the nation's air carrier airports, it should substantially reduce the overrun or off-runway type of hydroplaning/slippery runway accidents. As a possible look in the future, the Board believes that, under ice and snow conditions, it might be quite feasible to use an airport-owned diagonally-braked test vehicle to give actual day-by-day braking conditions for airport runways which could be relayed to incoming flights and/or dispatchers.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

September 16, 1970